NRZ EDC Proposal for 10GBASE-LRM

Presented by Michael Lawton, Agilent Technologies

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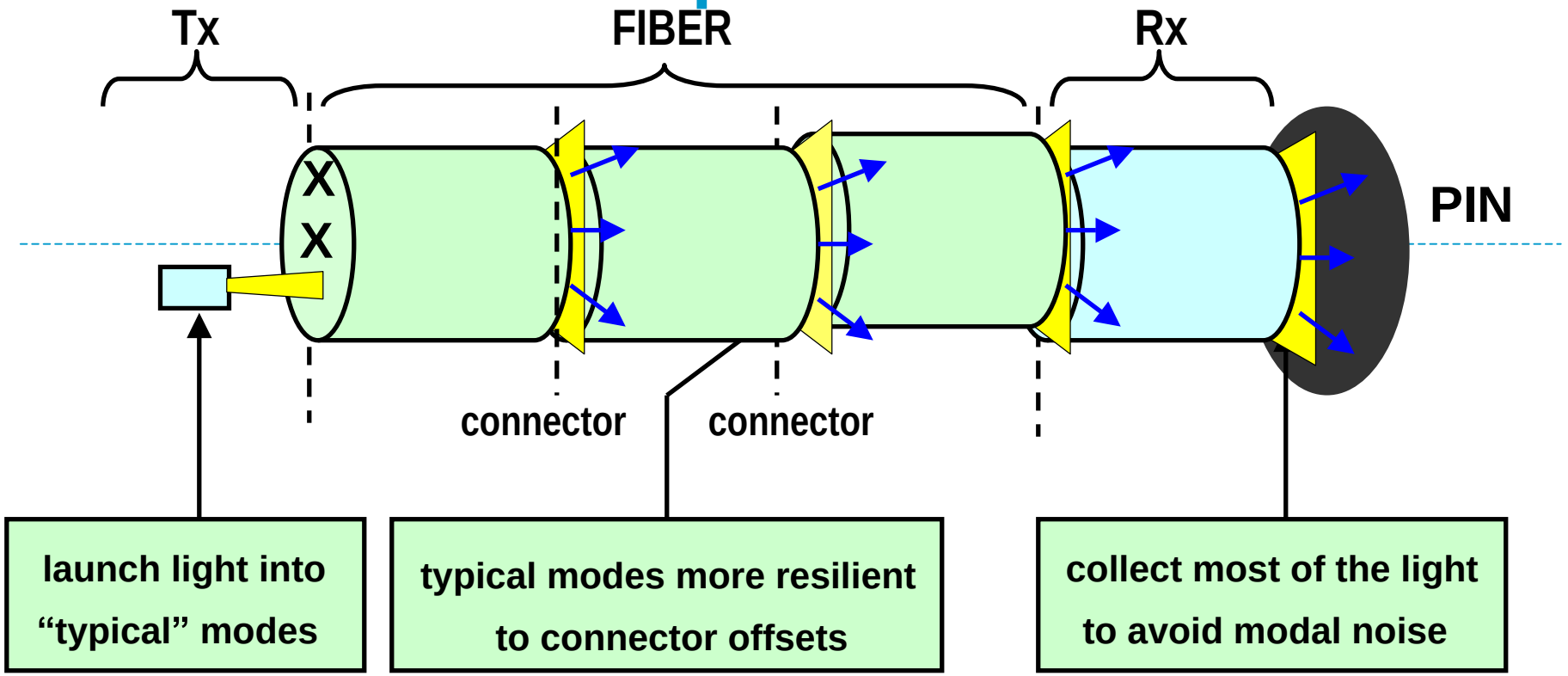
Summary

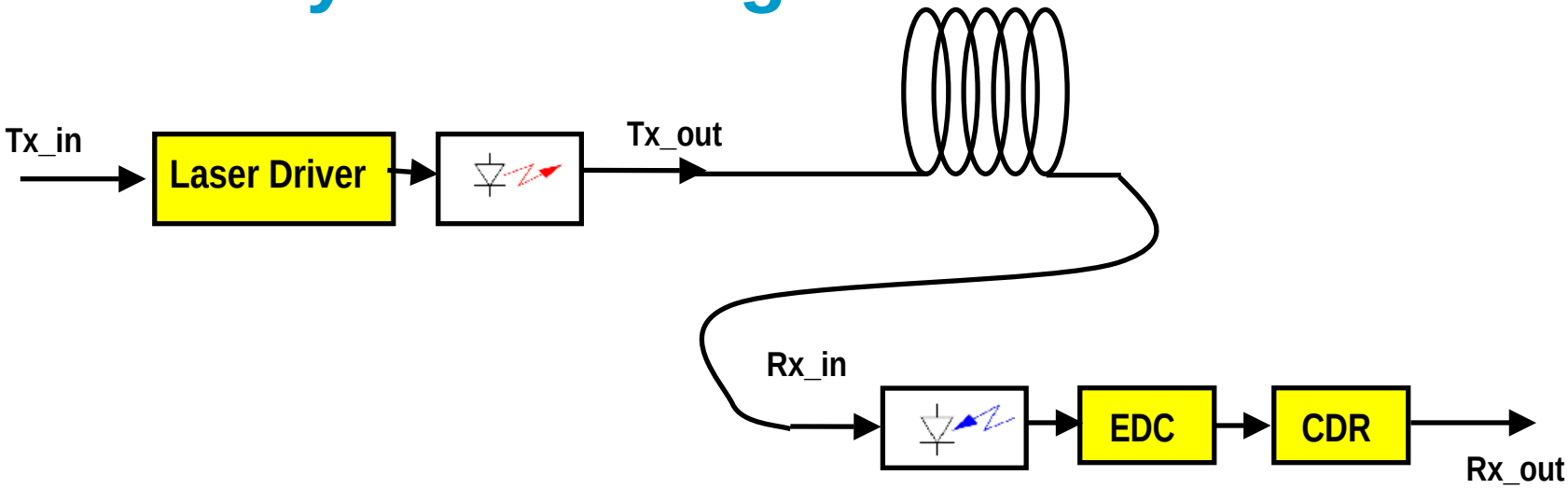
- **Motivation for an NRZ EDC proposal**
  - **Vendor support, technical feasibility, broadest implementation scope (source, launch, cheap electronics), timing**
- **Highlighted areas within the specification proposal:-**
  - **Parameters we can agree on today**
  - **Comparison with 10GBASE-LR (differences in blue)**
  - **Parameters in tables which warrant further study (shown in red)**
  - **Comments on implementation scope of the specification**
  - **Compliance testing strategy**
- **Draft Proposal Document also submitted.**

NRZ EDC Based Optical Path



Characteristic	Benefit
• Avoids polarization effects	Stability
• Modal noise penalty similar to 1000BASE-LX	low BER
• RIN noise penalty similar to 10GBASE-LR	cost, low BER
• Spectral requirements similar to 1000BASE-LX	cost

Availability of Building Blocks



Component	Availability
10G NRZ Laser Driver	Now
10G capable laser	Now
10G capable PIN	Now
10G EDC chip	2004
10G CDR	Now

- **Full suite of building blocks should be available by end of 2004**

Specification

- **Fiber types**
- **Transmitter characteristics**
- **Link Budget**
- **Receiver characteristics**
- **Compliance testing … to be further addressed by Lew Aronson**
- **Areas for further study**
- **Conclusions**

10GBASE-LRM Operating Range over each Fiber Type

Fiber Type	Modal bandwidth@ 1300nm min. overfilled launch (MHz.km)	Operating range (m)
62.5μm MMF	160/500 and 200/500	0.5 to 220
50μm MMF	400/500 and 500/500	0.5 to 220
50μm MMF	selected MMF (1500/500)	0.5 to 300

- **0.5m minimum range supports loop back testing**
- **Fiber type for 300m operation not defined**

Transmitter Parameters (TP2)

Description	Type	10GBASE-LR	10GBASE-LRM	Unit
Signaling speed	Nominal	10.3125	10.3125	GBd
Signaling speed variation from nominal	max	+/- 100	+/- 100	ppm
Center wavelength	Range	1260 to 1355	1260 to 1355	nm
RMS spectral width	max	NA	5	nm
Average launch power	max	0.5	0.5	dBm
Average launch power (informative)	min	-8.2	-7.5	dBm
Optical modulation amplitude	max		1.5	dBm
Optical modulation amplitude	min	-5.2	-4.5	dBm
Launch power of OFF transmitter	max	–30	–30	dBm
Extinction ratio	min	3.5	3.5	dB
$RIN_{12}OMA$	max	-128	-128	dB/Hz
Optical return loss tolerance	max	12	12	dB
Transmitter reflectance	max	-12	-12	dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3})		{0.25, 0.40, 0.25, 0.28, 0.4}	{0.25, 0.40, 0.25, 0.28, 0.4}*	
Encircled flux test for 50μm fiber		NA	>86% in 19μm radius <30% in 4.5μm radius	
Encircled flux test for 62.5μm fiber		NA	>86% in 24μm radius <30% in 4.5μm radius	

*** Relaxed eye mask TBD (subject of further study)**

Are there any Tx impairments that have not yet been captured?

Scope of implementation …

Description	Type	10GBASE-LR	10GBASE-LRM	Unit
Signaling speed	Nominal	10.3125	10.3125	GBd
Signaling speed variation from nominal	max	+/- 100	+/- 100	ppm
Center wavelength	Range	1260 to 1355	1260 to 1355	nm
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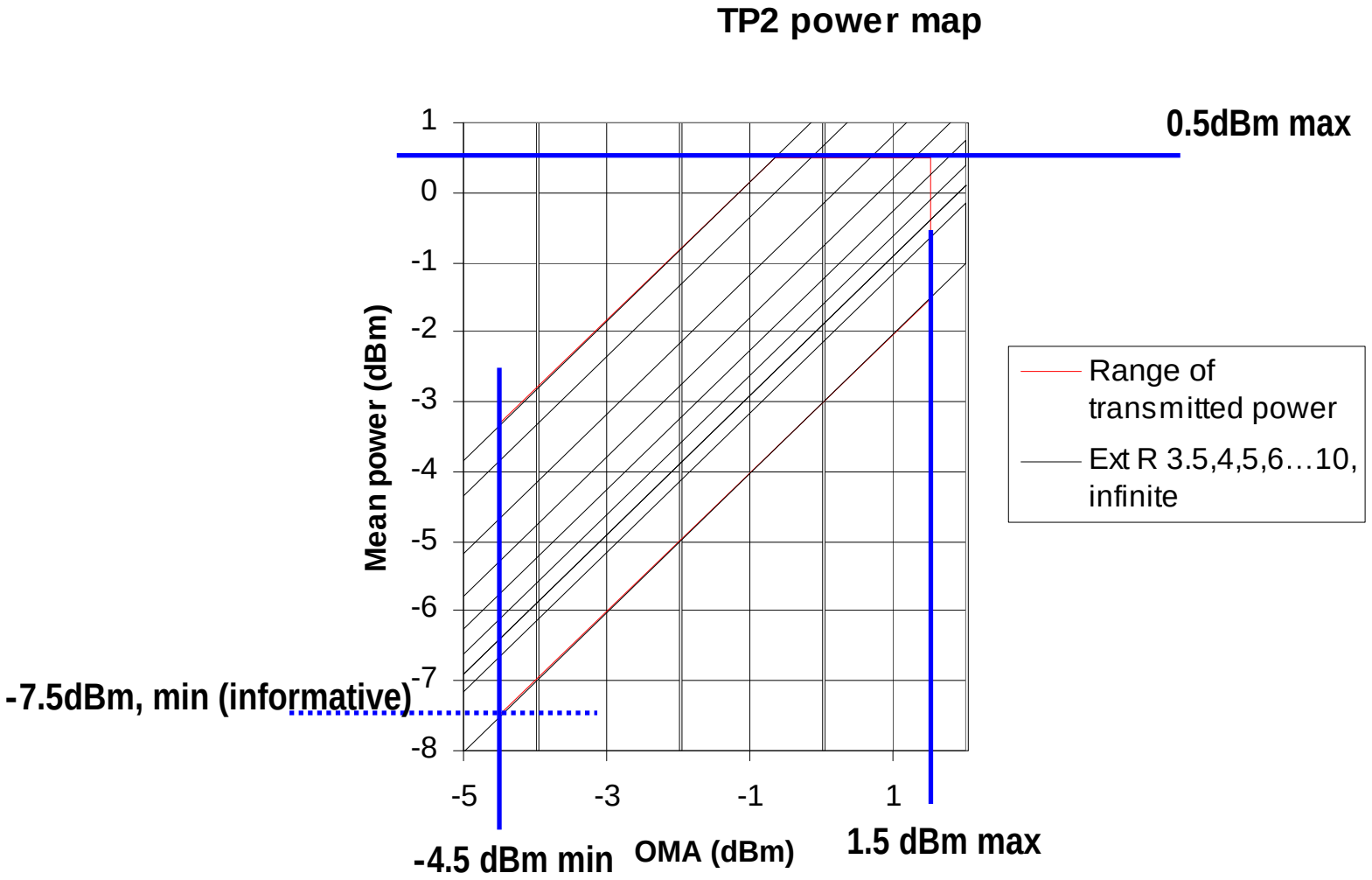
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3})		{0.25, 0.40, 0.25, 0.28, 0.4}	{0.25, 0.40, 0.25, 0.28, 0.4} relaxed tbd	
Encircled flux test for 50μm fiber		NA	>86% in 19μm radius <30% in 4.5μm radius	
Encircled flux test for 62.5μm fiber		NA	>86% in 24μm radius <30% in 4.5μm radius	

supports DFB/FP/VCSEL

relaxed eye margin?

low cost launch?

10GBASE-LRM Transmitter Power Window



- **Similar window to 10GBASE-LR (TDP=1.7dB)**

Link Power Budget for 220m (informative)

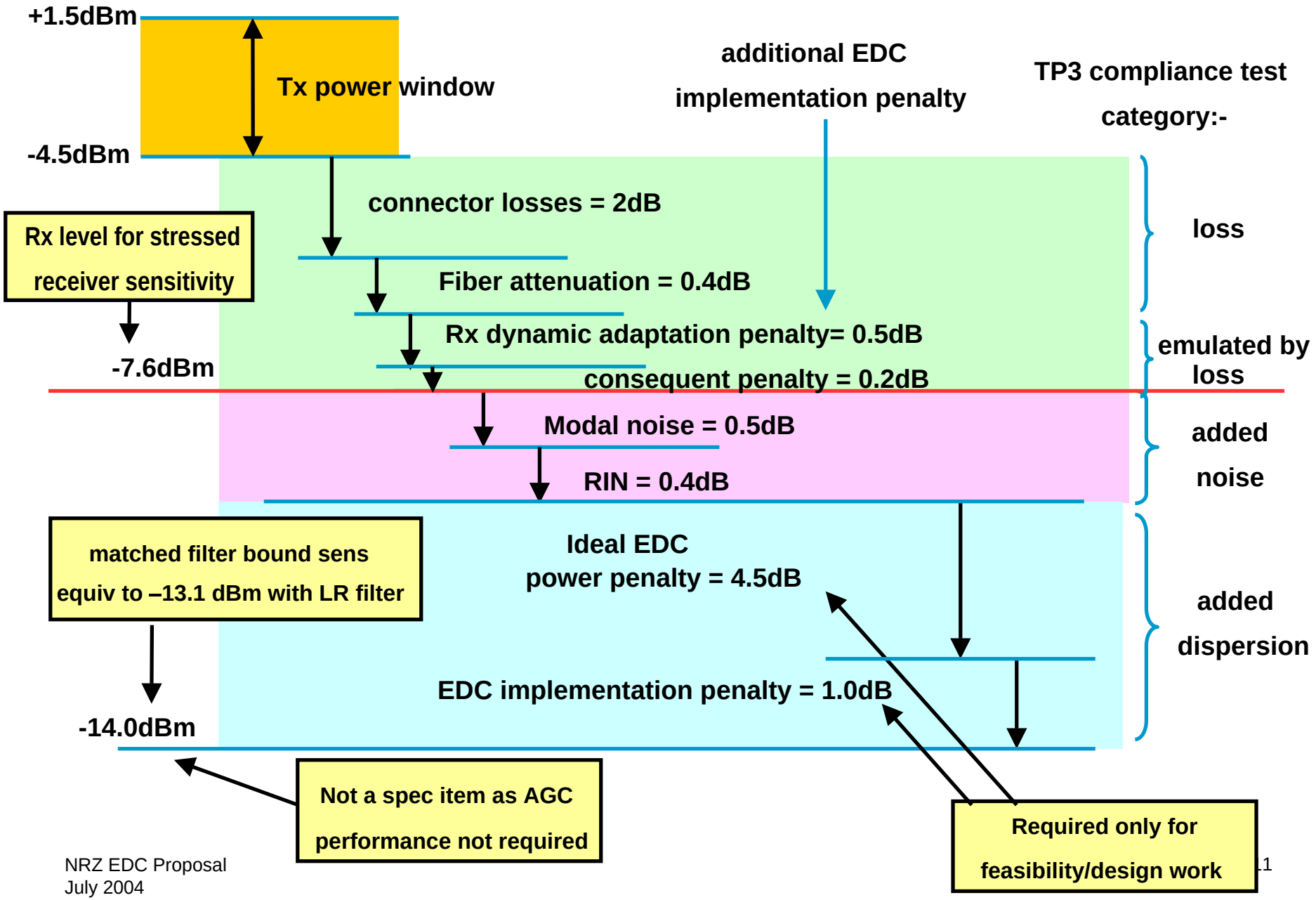
Parameter	Value	Units
Connector losses	2.0	dB
Fiber attenuation (220m)	0.4	dB
Modal noise penalty	0.5	dB
RIN penalty	0.4	dB
Rx Dynamic Adaptation Penalty	0.5	dB
Consequent Penalty	0.2	dB
Total	**4.0**	**dB**

Built into stressed Rx test

captured in an individual test

- **Link budget is very different for 10GBASE-LRM**
- **Dispersion allowance is not part of the 10GBASE-LRM link budget**
  - **Receiver specification and compliance testing determine the required dispersion performance**

Interpreting the EDC Link Budget (OMA)



TP3 Conformance Testing 10GBASE-LR …

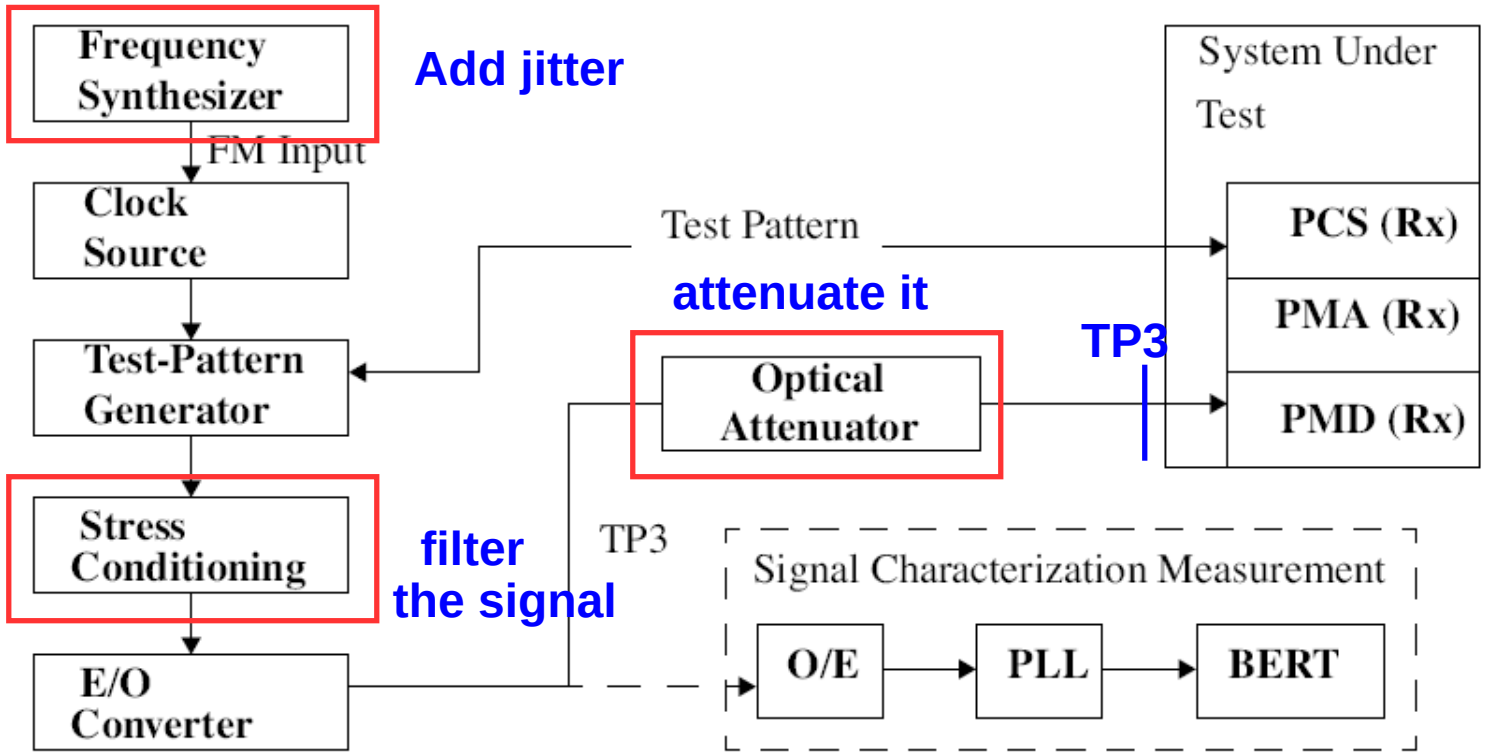
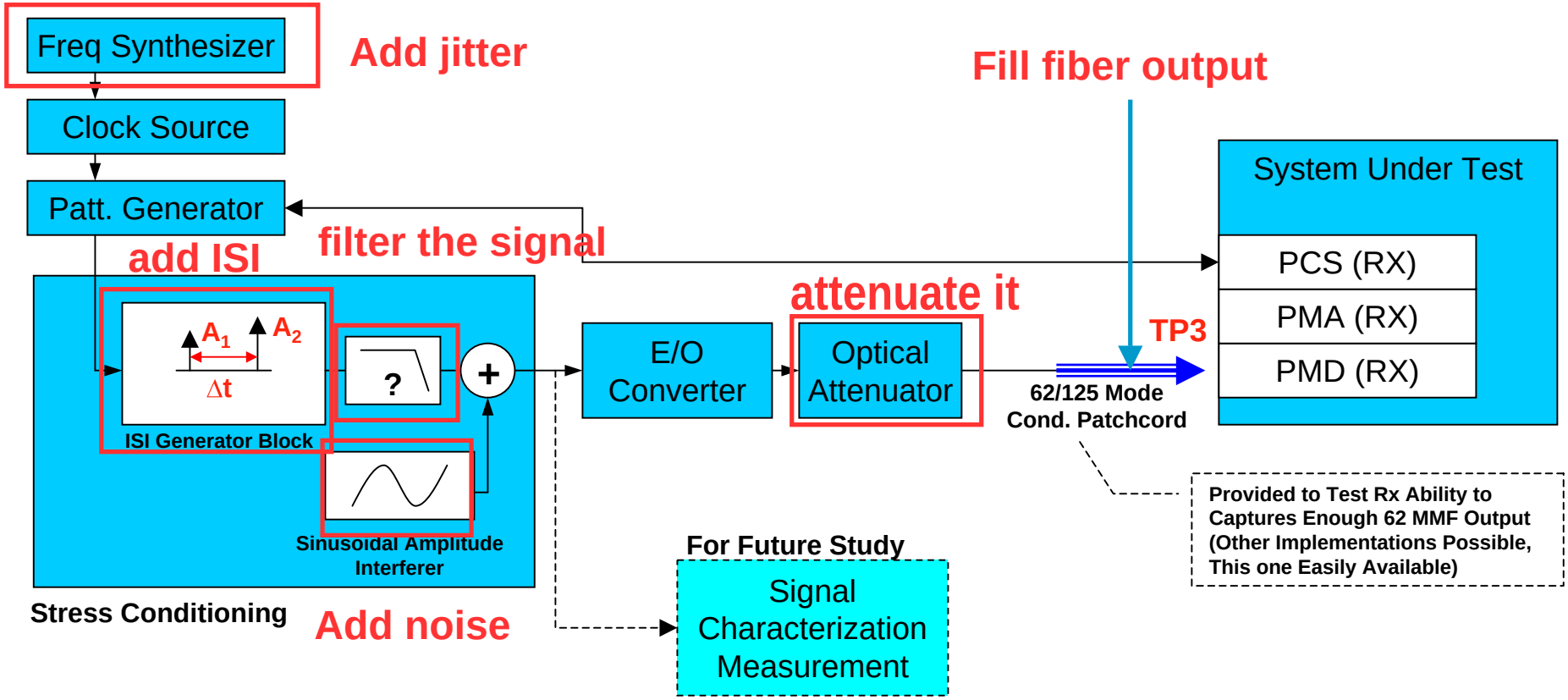


Figure 53–10—Receive jitter test block diagram

- **Diagram taken from 802.3ae**

TP3 Conformance Testing 10GBASE-LRM …



- **Diagram taken from presentation to be given by Lew Aronson**
- **Approach is similar to 10GBASE-LR with additional stress terms:-**
  - **Emulates ISI, Modal noise, RIN**

Receiver parameters (TP3)

Parameter	Type	10GBASE-LR	10GBASE-LRM	Units
Nominal signalling speed	nominal	10.3125	10.3125	GBd
Signalling speed variation from nominal	max	+/-100	+/-100	ppm
Center wavelength	range	1260 to 1355	1260 to 1355	nm
Average receive power	max	0.5	0.5	dBm
Received OMA	max		+1.5	dBm
Average receive power (informative)	min	-14.4	-9.9	dBm
Receiver sensitivity in OMA (informative)	max	-12.6	NA	dBm
Receiver sensitivity with ISI only in OMA	max	NA	???	dBm
(Static) Stressed receiver sensitivity in OMA (with ISI and sinusoidal jitter and noise applied)	max	-10.3	-7.6 (TBC)	dBm
Dynamic adaptation penalty	max		0.5	dB
Vertical eye closure penalty	min	2.2	Not used	dB
3dB electrical bandwidth	max	12.3	?	GHz

Areas for further study …

- **Transmitter**
  - **Eye mask specification**
  - **Determine launch test definition and limits**
  - **Extinction ratio**
- **Link budget**
  - **Agree dynamic adaptation penalty**
  - **Validate equalization penalties with channel model work**
- **Receiver**
  - **Define stressed test and limits**
    - **Receiver compliance testing to be addressed in a presentation by Lew Aronson**

Conclusions

- **NRZ EDC standardization progress:-**
  - **Demonstrated strong technical feasibility**
  - **Presented draft specification with broad scope for implementation**
  - **Transmitter is well defined with only two open issues:-**
    - **launch test**
    - **Relaxed Eye mask margin test**
  - **The link budget is defined (detailed validation required)**
    - **based on low mode dependent loss and resulting low modal noise penalty**
  - **Well considered proposals presented for conformance testing**
  - **Progress in line with standardization milestones**
- **Hardware progress supports timely product development**

Motion 8

- **Move that the 802.3aq task force adopt the NRZ EDC based proposal (lawton_01_0704) all of diagrams on page 10, 11 & 13 in aronson_2_0704 as the basis for on-going committee tasks in order to focus & progress the work towards a draft standard as modified according to the notes 1 and 2 below**

  Note 1: this motion does not change the draft TF timeline nor does it preclude new proposals from being brought forward in the September interim. It does direct the task force to work on key areas of the NRZ EDC proposal.

  Note 2: All the table entries in lawton_01_0704 in red & all of diagrams from pgs 10, 11 & 13 in aronson_2_0704 shall be considered and identifed as 'TBD', with a corresponding Editors note based upon the placeholder value to be considered by the value/parameter in red

  - **Moved: Mike Lawton Second: Pete Hallemeier**

Y/N/A 59/0/2

Motion 8 Motivation

- **Motivation:**
  - **As of the 7/04 Portland meeting, the task force has a single multi-company proposal under consideration**
  - **There are a number of key work items which would better progressed as part of the larger Task Force**
    - **Similar to the activities of the Channel Ad-hoc**
  - **The best opportunity to progress the efforts towards the draft timeline will be through a focused Task Force effort on a path which can achieve 75% support**
- **Potential example 802.3aq tasks to get to a D1.0:**
  - TP2 related items**: conditioned launch, eye mask, TDP, …**
  - TP3 related items**: stressed Rx sensitivity test, Dynamic Adaptation Test, Informative Rx Sensitivity, …**
- **Why we can make forward progress now:**
  - **NRZ EDC viability based upon numerous simulation & experimental data**
    - **Cambridge Worst Case model, 802.3z MBI data set, 'Worst Case SX' fiber, '12/96 Modal BW Demo' fiber, '10GbE Demo Cable' fiber,… -** most at 300m lengths
  - **Several metrics under consideration – all with margin to the straw-man budget**
  - **If/when a the channel model is revised with the associated statistics, easy to evaluate the impact on the link budget**

Items in red …

- **Definition of MMF for 300m**
- **Tx**
  - **Eye mask specification**
  - **Launch test**
  - **Extinction ratio**
  - **Additional Tx impairments**
- **Link Budget**
  - **ISI Adaptation penalty**
- **Rx**
  - **Static Rx stressed test**
  - **Dynamic Rx stressed test**
  - **Normative Rx sensitivity (in presence of ISI) test**

TP3- Normative (Static) Stressed Sensitivity Test (page 10 aronson_02_0704)

Goals:

Simplest Test Which Adequately Stresses EDC – Start Really Simple!

Reuse as Much 10GBASE- LR Stressed RX Test Hardware As Practical

Avoid User Tradeoff Choices Allowed in –LR Stressed Test

Proposed Parameters (to be included in 10GBASE-LRM receive characteristics table)

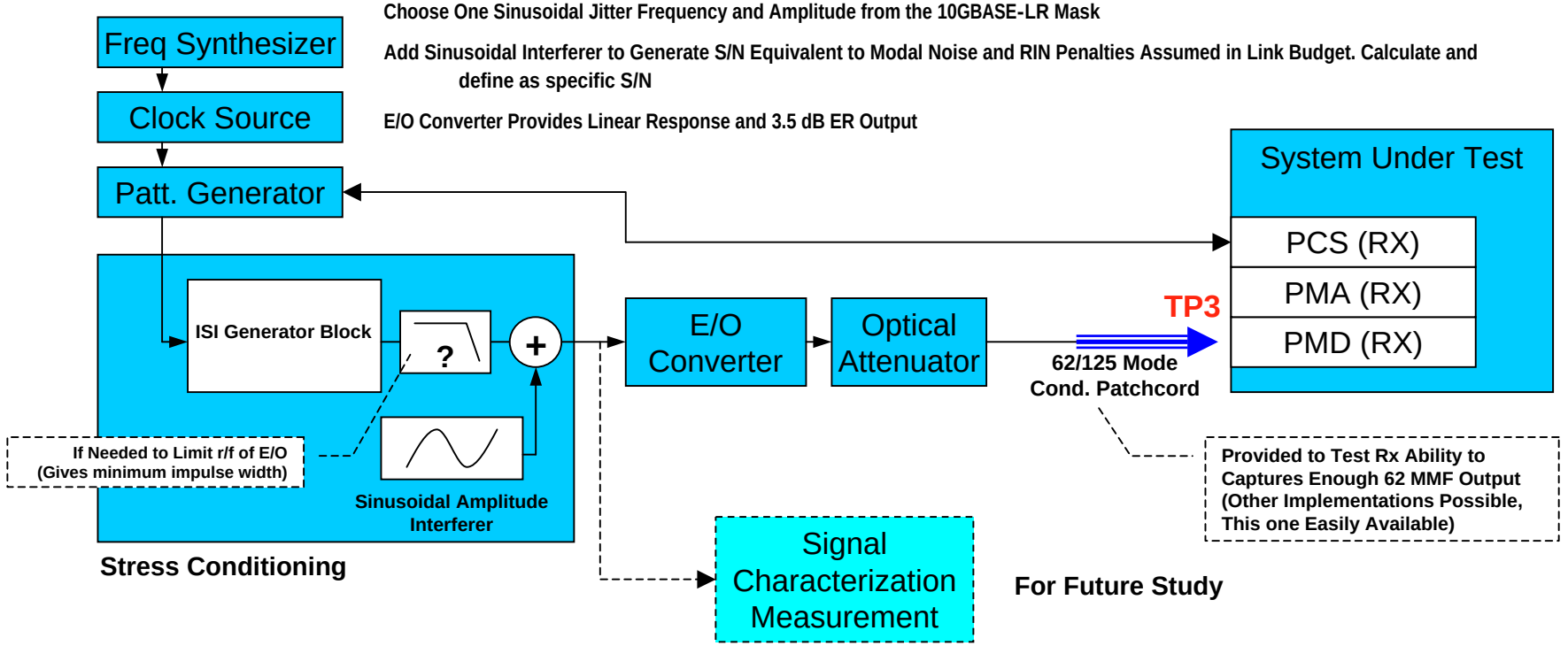
2 Peak Impulse Response.

- A_2/A_1 ~ 1.5 (?)
- Δt Chosen to Yield Target Figure or Merit (Based on Allocated EDC Link Penalty) and Representative of DMD span of channel model

Choose One Sinusoidal Jitter Frequency and Amplitude from the 10GBASE-LR Mask

Add Sinusoidal Interferer to Generate S/N Equivalent to Modal Noise and RIN Penalties Assumed in Link Budget. Calculate and define as specific S/N

E/O Converter Provides Linear Response and 3.5 dB ER Output



TP3- Adaptation Speed Test

(page 11 aronson_02_0704)

Goals:

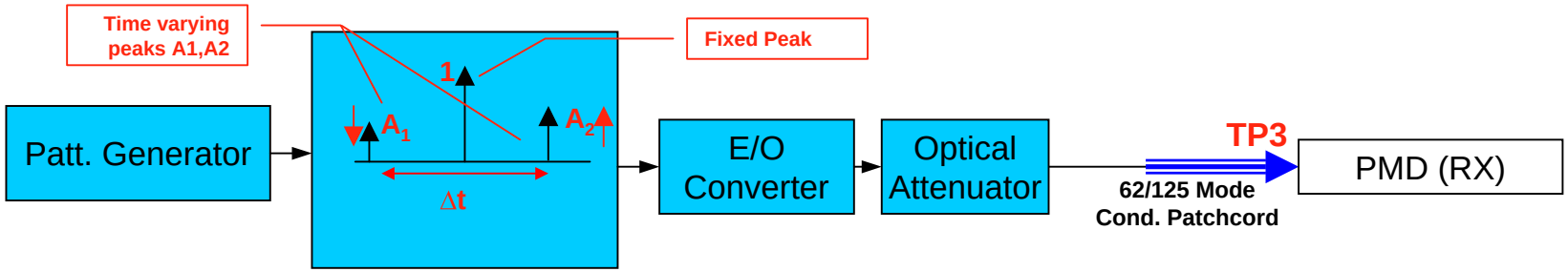
Simplest Test to Establish Adequate EDC Adaptation Speed

- Decouple from Stressed RX Test, Do not Include SJ and Amplitude Noise
- Likely Used Only in IC Development and XCVR Design Verification, But Still Normative

Choose Minimum OMA and Test for < 1e-12 BER Over Minimum ISI Cycle

Is an Initialization Time Spec / Test Needed or is it Implicit in Form Factor MSAs

Probably needed but outside scope of IEEE specification



Shift Power Sinusoidally and Completely Between A_1 and A_2 But Retain A Larger Fixed Peak Specify Adaptation Rate in Receive Characteristics Table

Rate of Oscillation Cycle Between A_1 and A_2

Chosen using Measurement Experiments on Time Variation of Perturbed Fiber Link

Measure Penalty for Dynamic (At Specified Test Rate) vs Static ISI

Static case probably being the worst specific ISI case in the dynamic cycle, OR

Same much slower (1000x?) rate

Parameters included in 10GBASE-LRM Receive Characteristics Table.

TP3- Simple Informative Sensitivity Test
(page 13 aronson_02_0704)

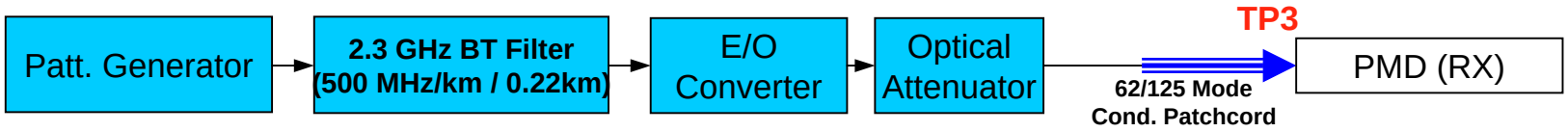
Goals:

EDC Relevant Test Equivalent to Informative Basic Sensitivity Test in 802.3ae

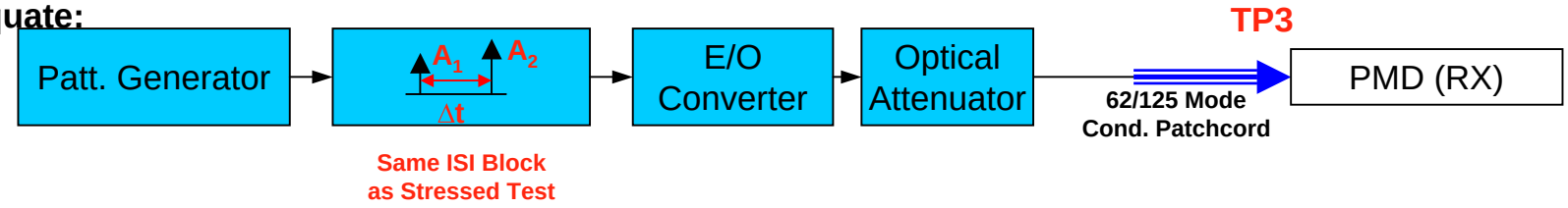
Low Noise, No SJ Signal with Simple ISI Block

Provide Simplest Test For Use in Day-to-Day Measurements Such as Manufacturing

Option 1 - Simplest:



Option 2 – If Option 1 is Considered Inadequate:



Need to Calculate Required Informative Sensitivity for Receive Characteristics Table

Not a Clear Way to Do So, Requires Further Study